MASTER OF SCIENCE
IN
ASTRONAUTICAL ENGINEERING

DEVELOPMENT AND CONTROL OF A THREE-AXIS SATELLITE SIMULATOR FOR THE BIFOCAL RELAY MIRROR INITIATIVE

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The Three Axis Satellite Simulator (TASS) is a 4-foot diameter octagonal platform supported on a spherical air bearing. The platform hosts several satellite subsystems, including rate gyros, reaction wheels, thrusters, sun sensors, and an onboard control computer. This free-floating design allows for realistic emulation of satellite attitude dynamics in a laboratory environment.

The bifocal relay mirror spacecraft system is composed of two optically coupled telescopes used to redirect the laser light from ground-based, aircraft-based or spacecraft based lasers to distant points on the earth or in space for a variety of non-weapon, force enhancement missions. A developmental version of this system was integrated onto the TASS as an auxiliary payload.

The objective of this thesis was to develop and test the integrated optics and TASS system. This effort included hardware design, fabrication, and installation; platform mass property determination; and the development and testing of control laws and signal processing routines utilizing MATLAB and SIMULINK. The combination of the TASS with the bifocal relay mirror payload allowed for dynamic, real-time testing and validation of the target acquisition, tracking, and laser beam pointing technologies as well as satellite stabilization.

KEYWORDS: Attitude Determination, Attitude Control, MATLAB, SIMULINK, Satellite Simulator, Air Bearing

CHARACTERIZATION AND PERFORMANCE OF A LIQUID HYDROCARBON-FUELED PULSE DETONATION ROCKET ENGINE

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A liquid hydrocarbon-fueled PDRE was built and successfully tested at the Naval Postgraduate School's Rocket Propulsion and Combustion Laboratory. The first time use of a new electro-hydraulic liquid fuel injector was demonstrated to produce consistent atomization properties while allowing for varying fuel injection durations at frequencies up to 50Hz. Planar laser-induced fluorescence and high-speed imaging were used to characterize the injection flow paths of this injector.

Using gaseous ethylene as a baseline for comparison, the PDRE was operated at various equivalence ratios and frequencies up to 40 Hz. Operation in partial fill scenarios was successfully conducted and found to deliver a decreased impulse linearly related to the percentage fill.

A series of tests was conducted using liquid JP-10 and RP-1 fuels over varying oxidizer-to-fuel ratio. The higher pressures, wave speeds, and resulting impulse measurements revealed the benefits of using high

energy density hydrocarbon fuels. The difficulty in detonating these fuels was demonstrated and overcome using a variety of different geometries and hardware configurations.

KEYWORDS: Detonation, Pulse Detonation Rocket Engine, Hydrocarbon Fuels, Space Propulsion

ROCKET PLUME TOMOGRAPHY OF COMBUSTION SPECIES

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Interest in accurate detection and targeting of aggressor missiles has received considerable interest with the national priority of developing a missile defense system. Understanding the thermal signatures of the exhaust plumes of such missiles is key to accomplishing that mission. Before signature models can be precisely developed for specific rockets, the radiation of the molecular or combustion species within those plumes must be accurately predicted. A combination translation / rotation scanning diagnostic technique has been developed to map the combustion species of a rocket plume and characterize its radiation properties. Using new infrared spectrometer and fiber optic cable technology to transmit the signal spectrum of interest, the custom designed mechanism can sweep through two dimensions of a steady-state rocket exhaust. A glow bar, or blackbody simulator, is shuttered on the opposite side of the plume, allowing the spectrometer to measure both the emission and absorption spectra. This thesis demonstrated the first time use of fiber optic cable to transmit infrared emission / absorption (E/A) spectra from a rocket plume to an infrared detector. This new fiber optic configuration allows for rapid translation and rotation around the rocket plume, establishing the capability for rapid spatial characterization of the combustion species present. Experimental results may then be compared to DoD rocket plume model predictions to highlight areas for improvement.

KEYWORDS: Rocket Plume Exhaust, Spectral Imaging, Emission / Absorption, Combustion Species, Signature